



Everglades Restoration and the Florida Keys National Marine Sanctuary: Monitoring for Possible Ecosystem Effects

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The Florida Keys

- Florida Keys Reef Tract 350 km long - S. of Miami to Dry Tortugas
- Nationally significant system of mangroves, seagrass beds, & coral reefs
- Near northern limit of Atlantic coral reef development - generally little accretion over the past 6,000-7,000 years of reef growth
- Major declines in live coral cover over the past 30 yr - Caribbean-wide
- Bleaching events:
1997-98 1st global
- Diseases
- Overfishing



The system may not be very resistant or resilient to additional stressors

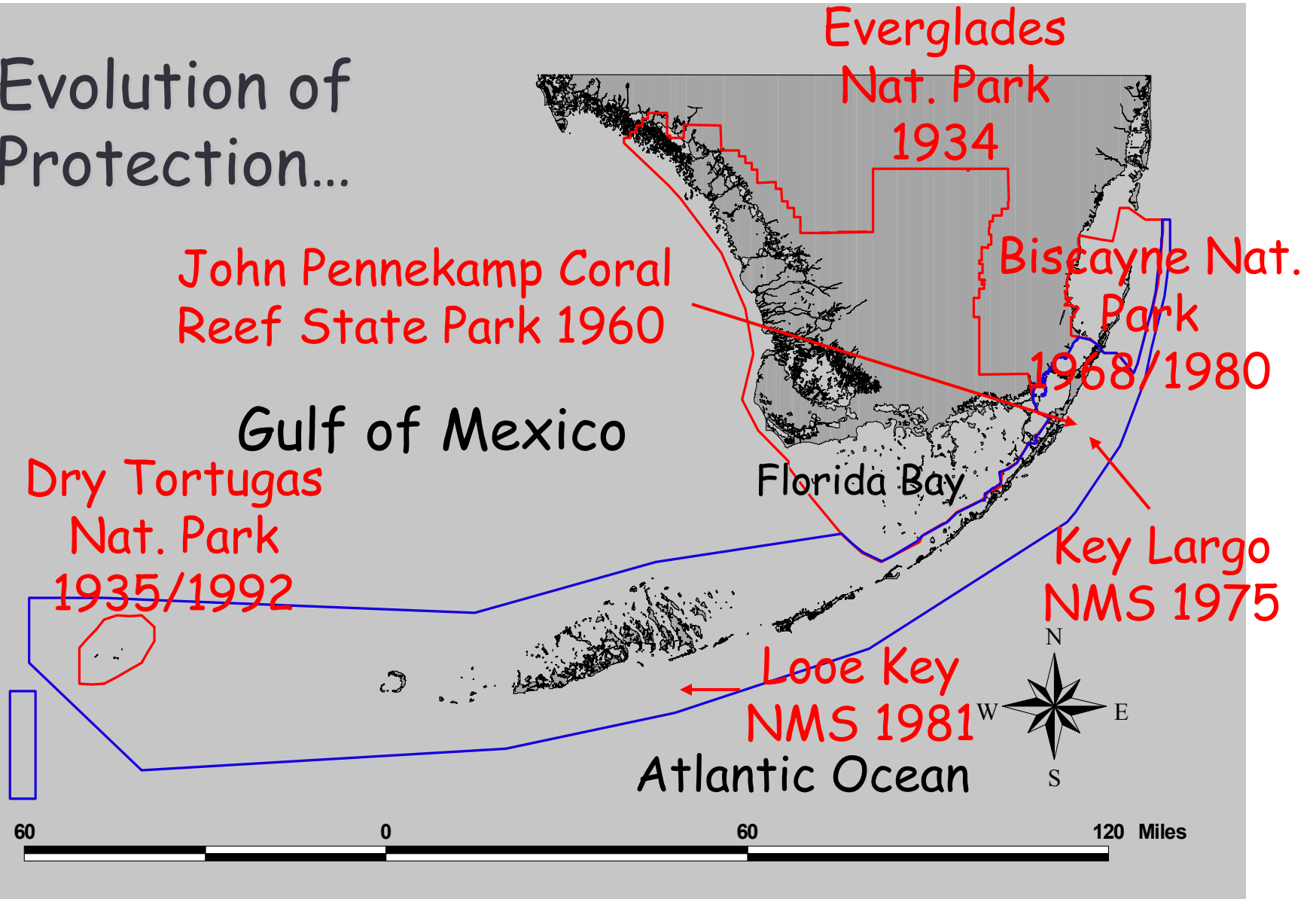


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South Florida Marine Ecosystem

Evolution of Protection...

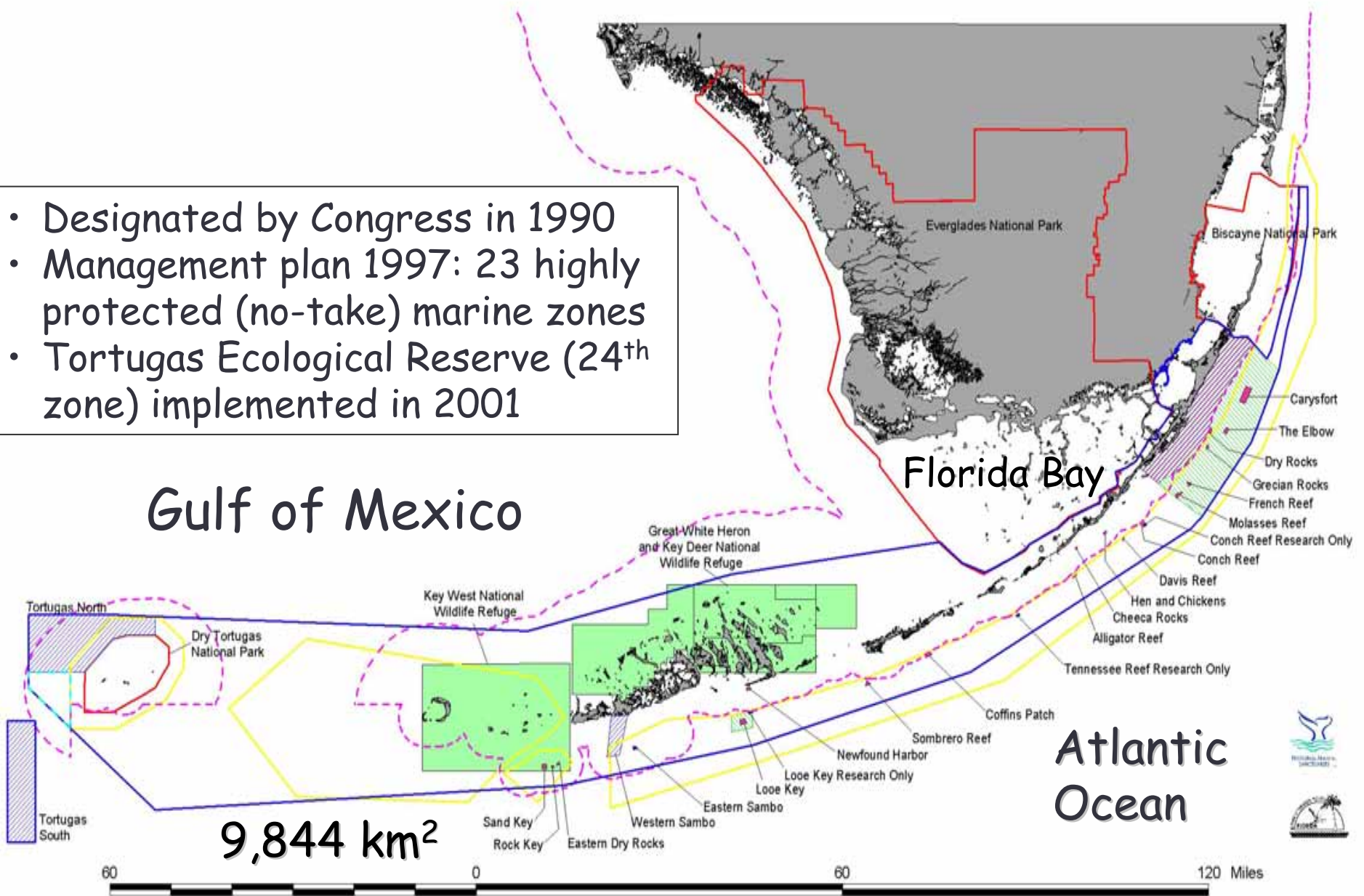


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Florida Keys National Marine Sanctuary

- Designated by Congress in 1990
- Management plan 1997: 23 highly protected (no-take) marine zones
- Tortugas Ecological Reserve (24th zone) implemented in 2001



Connectivity Between Southwestern Florida and the Florida Keys

BULLETIN OF MARINE SCIENCE, 80(1): 21-43, 2007

SEASONAL VARIABILITY IN NUTRIENT AND PHYTOPLANKTON DISTRIBUTIONS ON THE SOUTHWEST FLORIDA INNER SHELF

Jennifer L. Jurado, Gary L. Hitchcock, and Peter B. Ortner

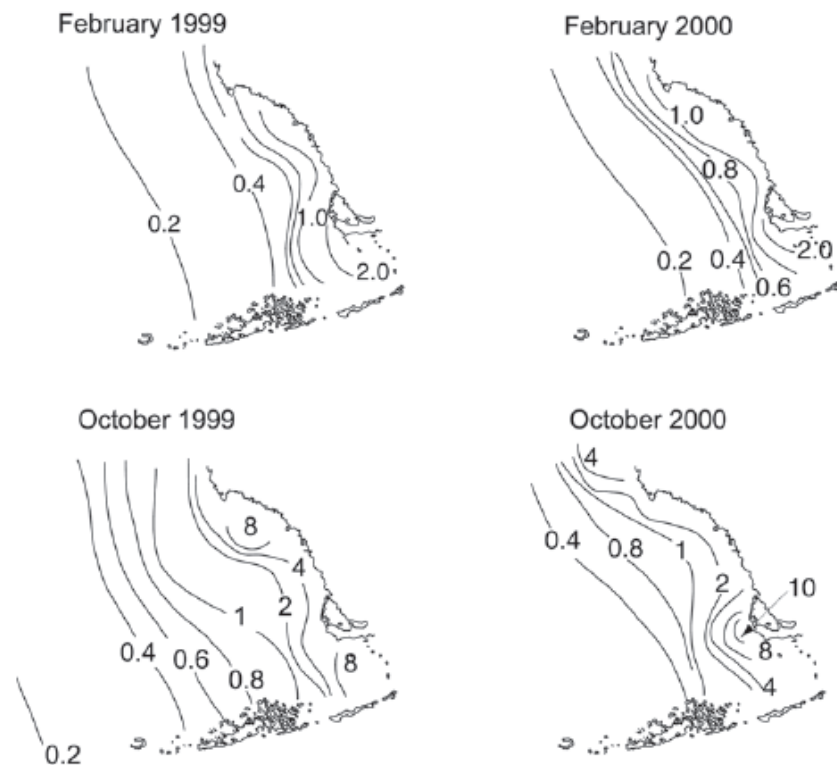


Figure 8. Surface distributions of Chl a concentration on the inner shelf and in western Florida Bay during February (dry season) and October (wet season) 1999 and 2000.

Diatom bloom began Apr-Jun near Cape Sable during peak discharge/nutrient flux from Shark River watershed

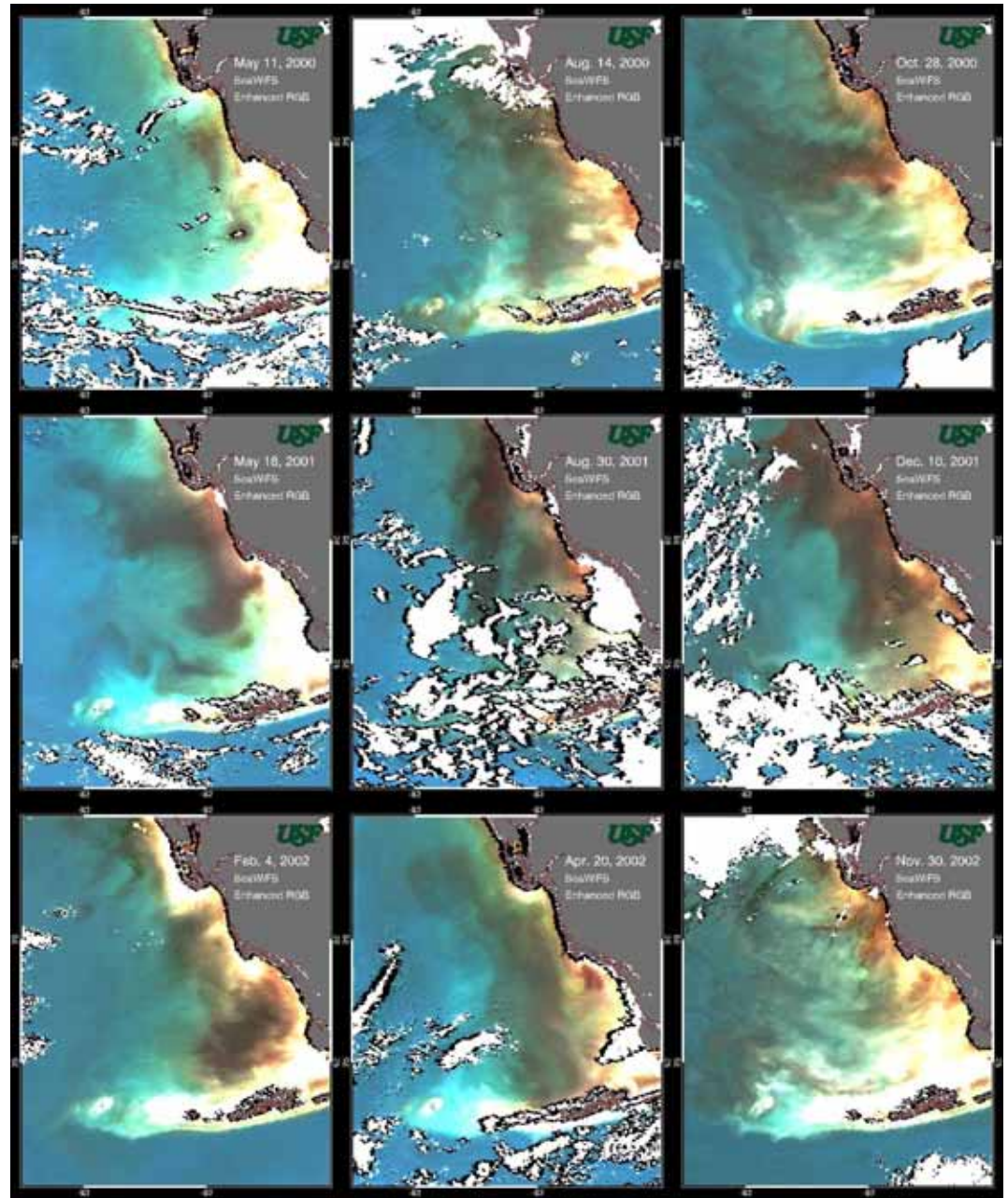


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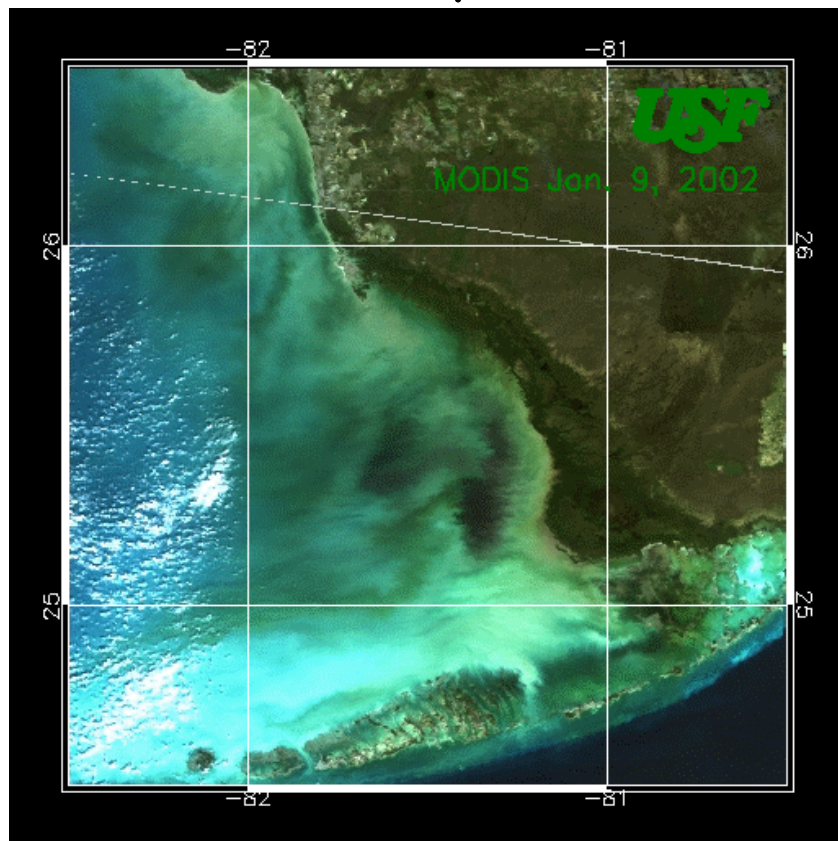
Hu and Muller-Karger 2008

- 1997-2004 SeaWiFS & MODIS images
- Dark water plumes or patches not uncommon
- 1997, 2000, & 2002 "streamers" from Everglades
- 1998, 2001, & 2003 dark water from near Charlotte Harbor to the Tortugas

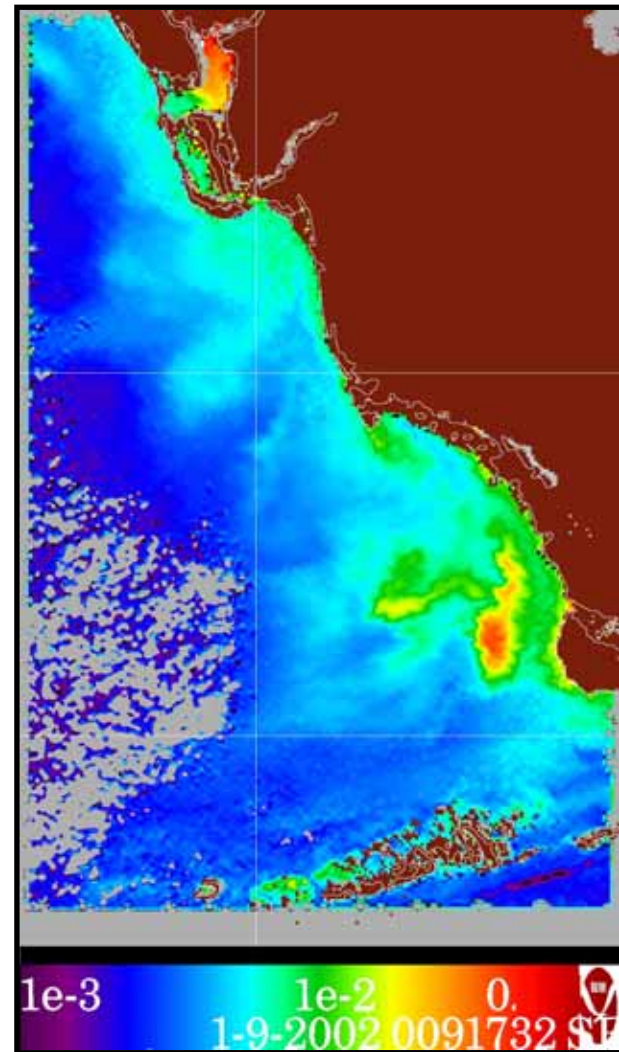


Blackwater Event: Winter 2001-2002

9 January 2002



True color image



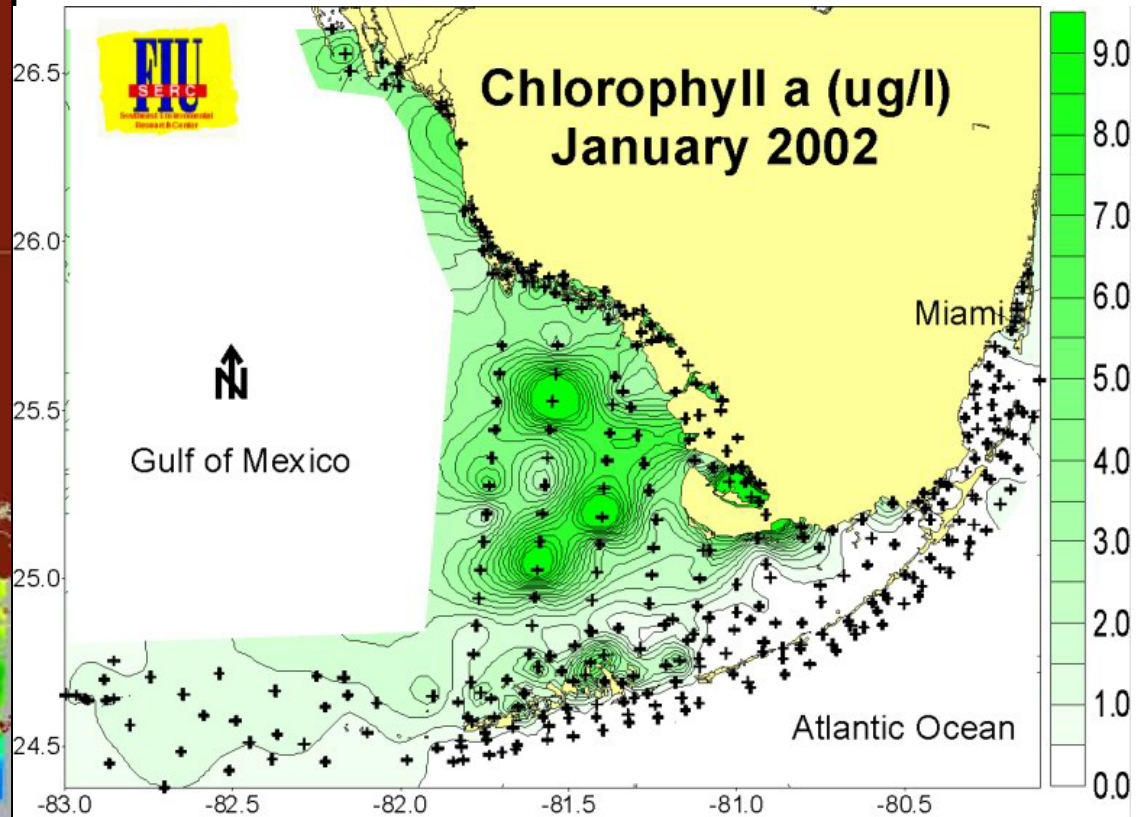
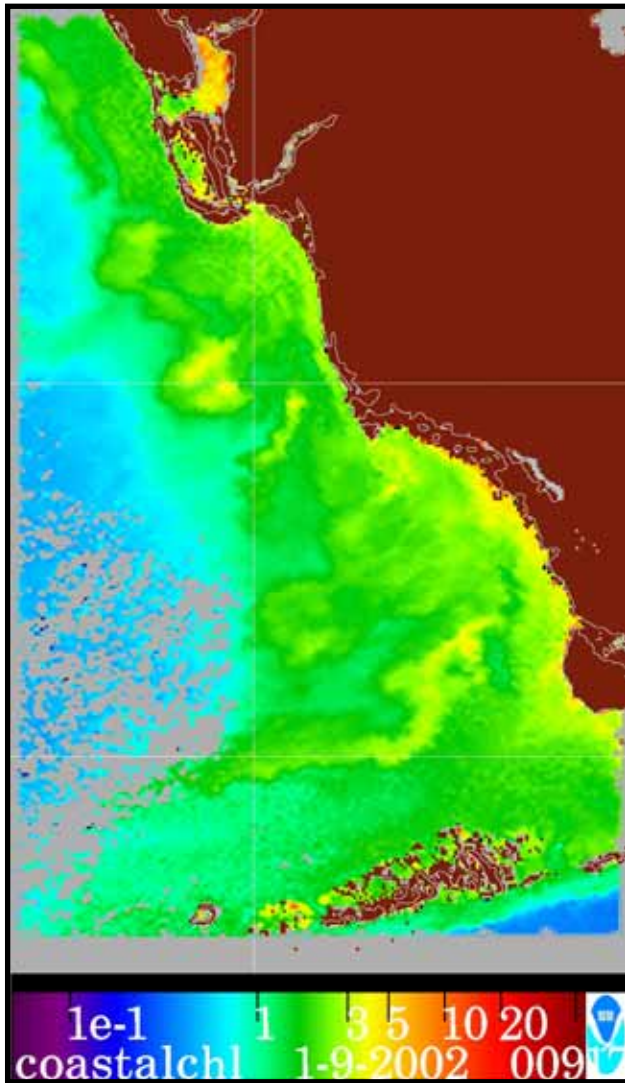
R. Stumpf, NOAA CoastWatch

Image enhanced for blackwater
"signal" (tannins, humic acid)



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R. Stumpf, NOAA CoastWatch

1/9/02: Image enhanced for chlorophyll concentration (amount of phytoplankton)

Highest concentration of chlorophyll *a* measured in this region since quarterly monitoring began in 1995

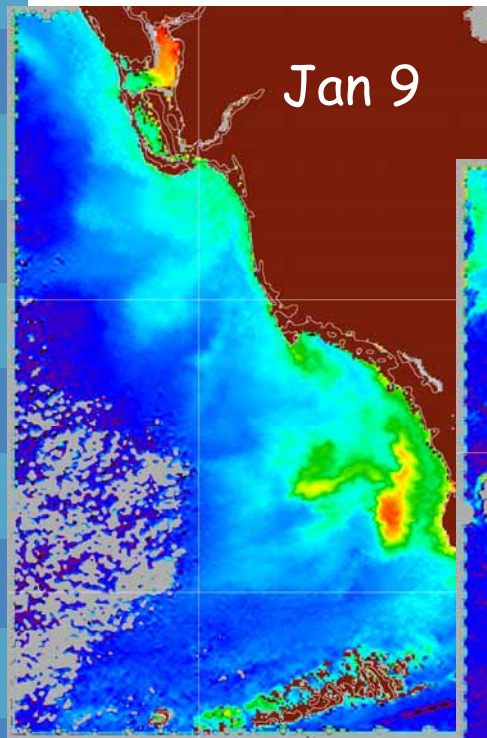
(Courtesy J. Boyer, FIU/SERC)



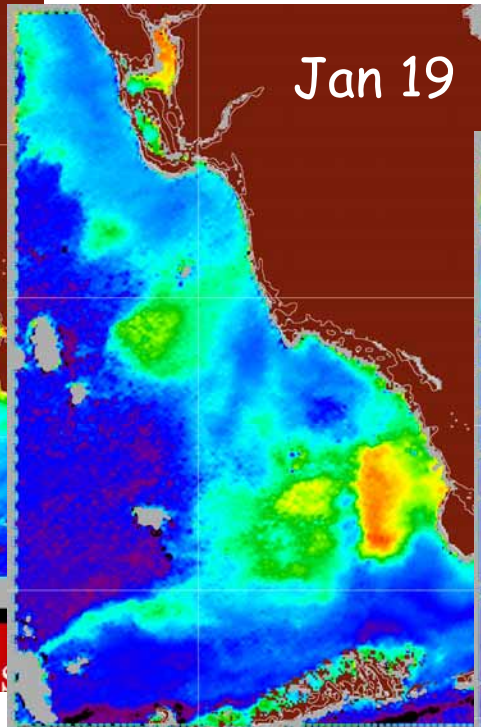
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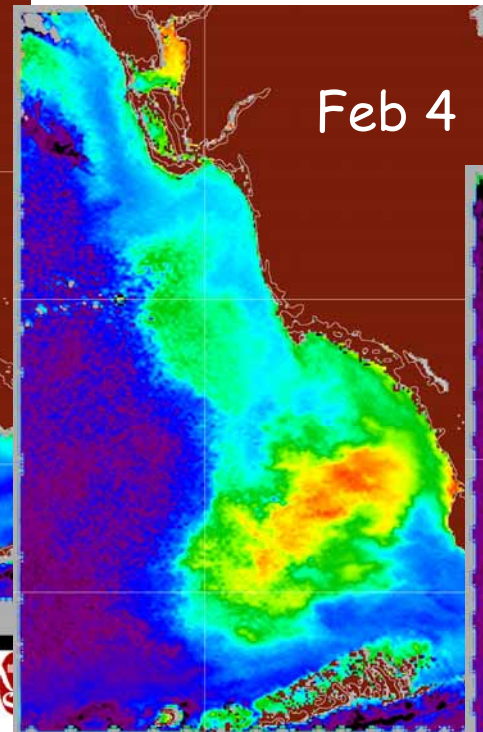
2002 Transport of Blackwater



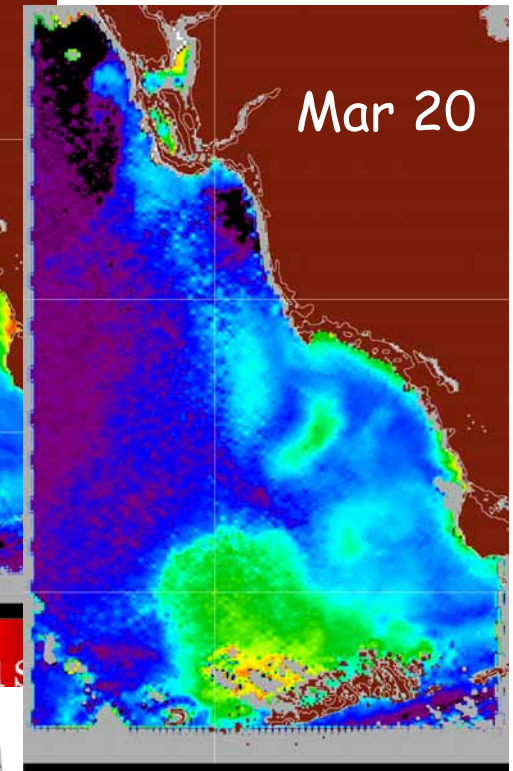
1e-3 1e-2 0
1-9-2002 00917328



1e-3 1e-2
1-19-2002 01917598



1e-3 1e-2
2-4-2002 03517418



1e-3 1e-21
3-20-2002 07917188

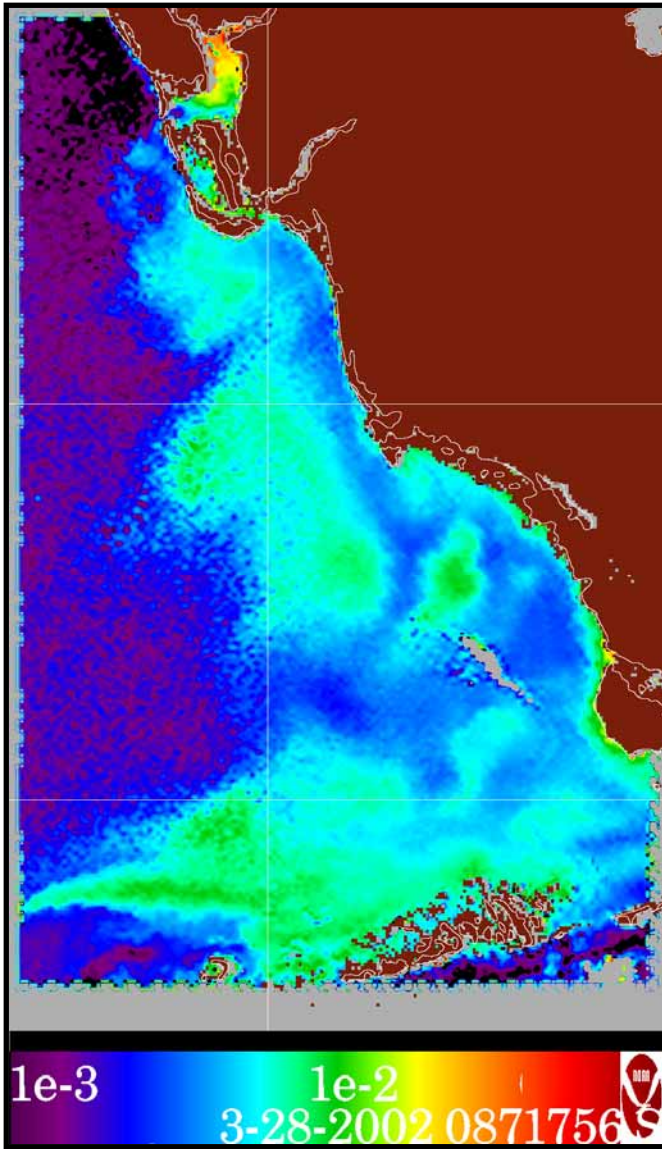
R. Stumpf, NOAA CoastWatch



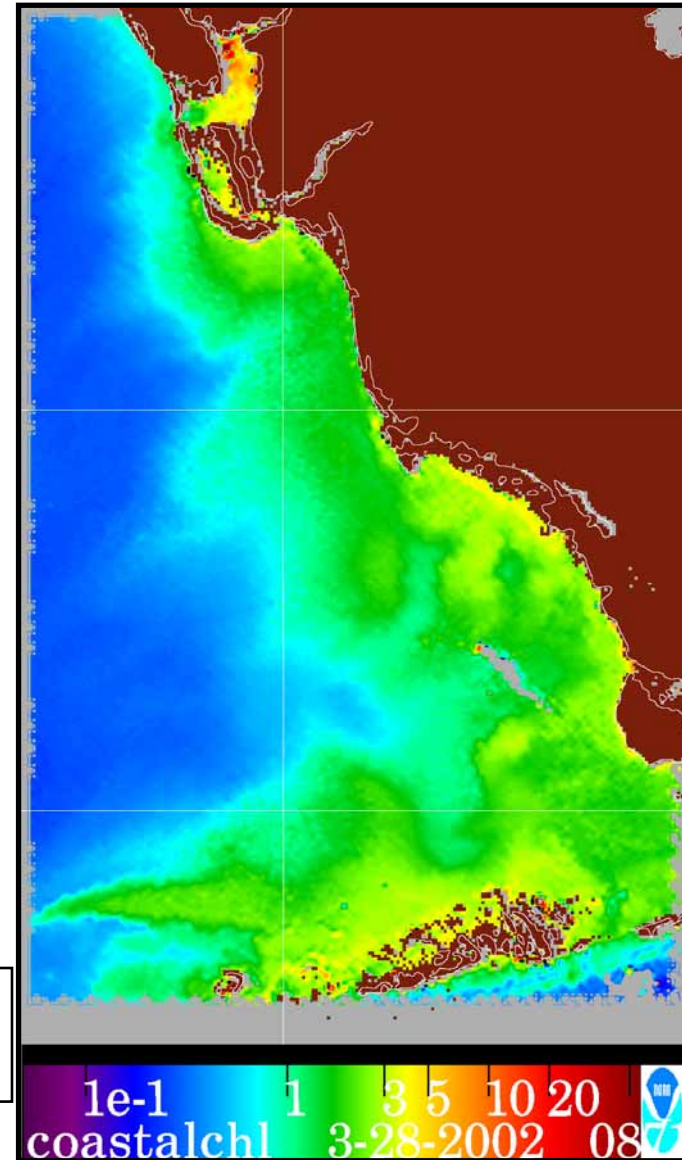
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Blackwater



Plankton



R. Stumpf
NOAA

28 March 2002: remnant blackwater and plankton bloom branching westward north of the Marquesas and moving through the Lower Keys
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Advection of a Harmful Algal Bloom in 2004



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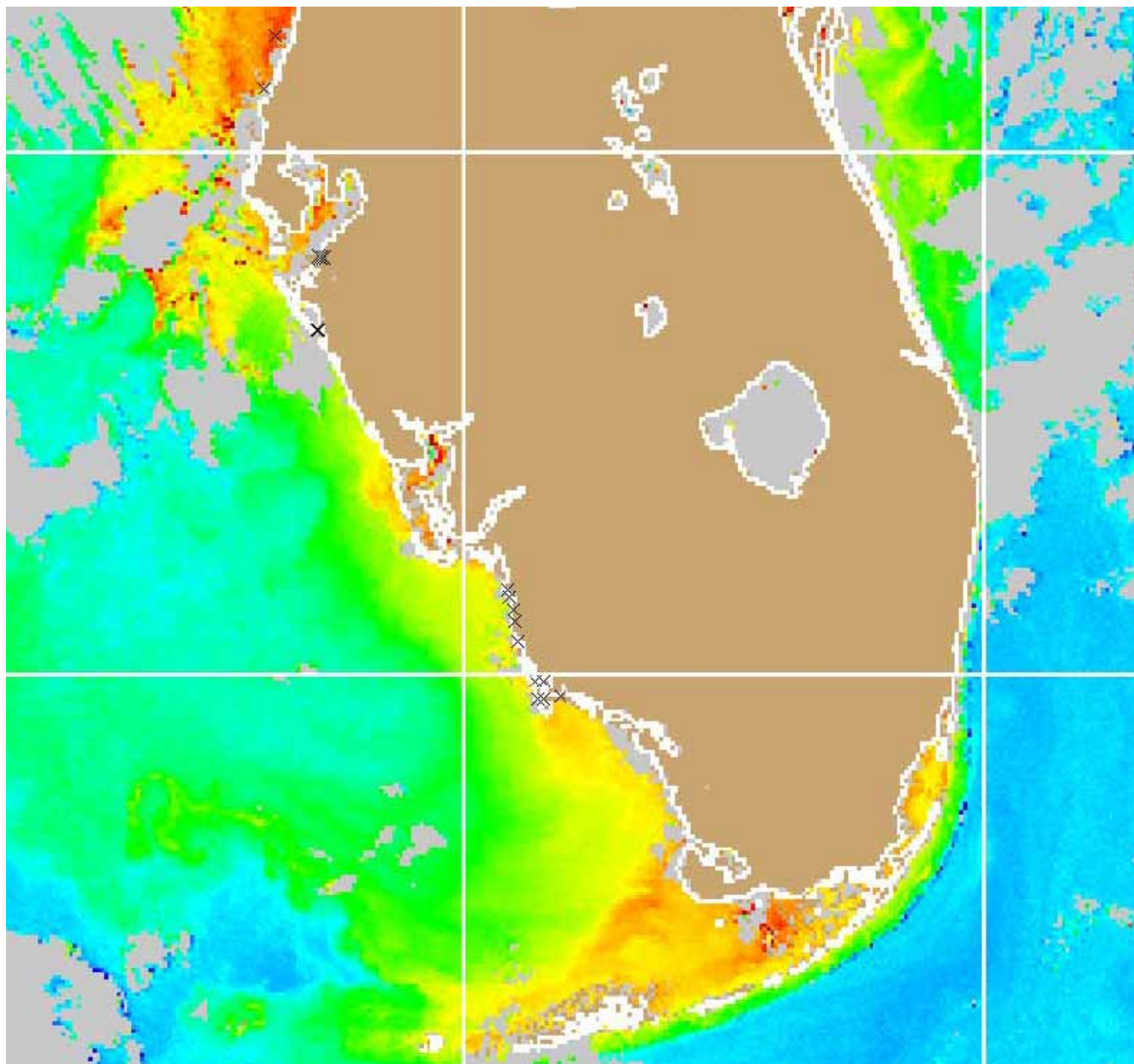
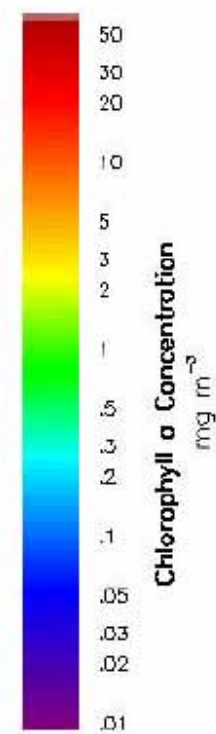
CoastWatch

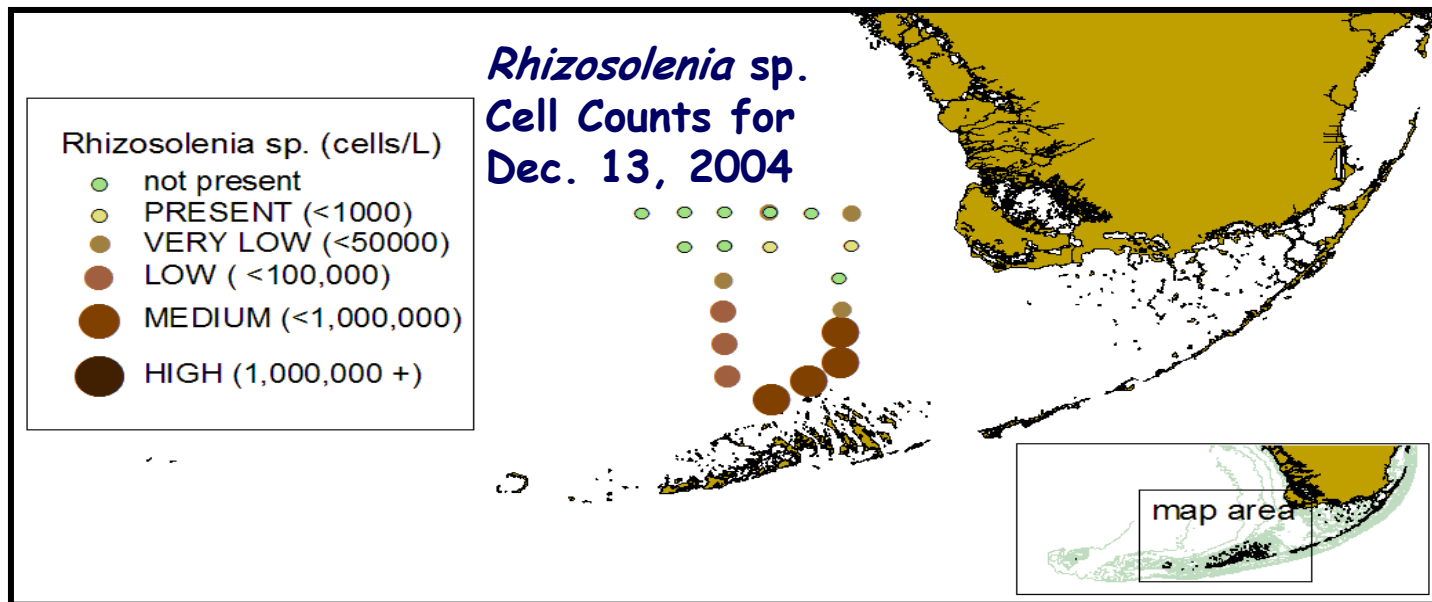
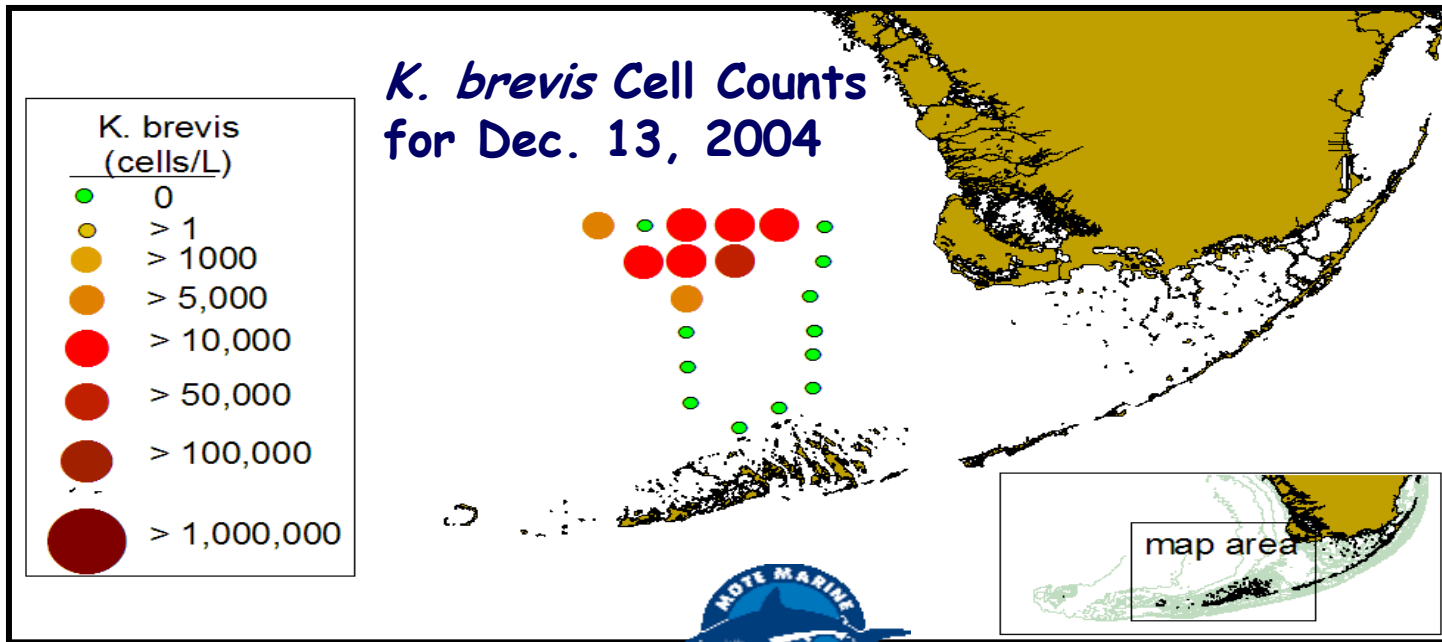
2005 JAN 8 17:57:51 GMT

Full Region Gulf of Mexico

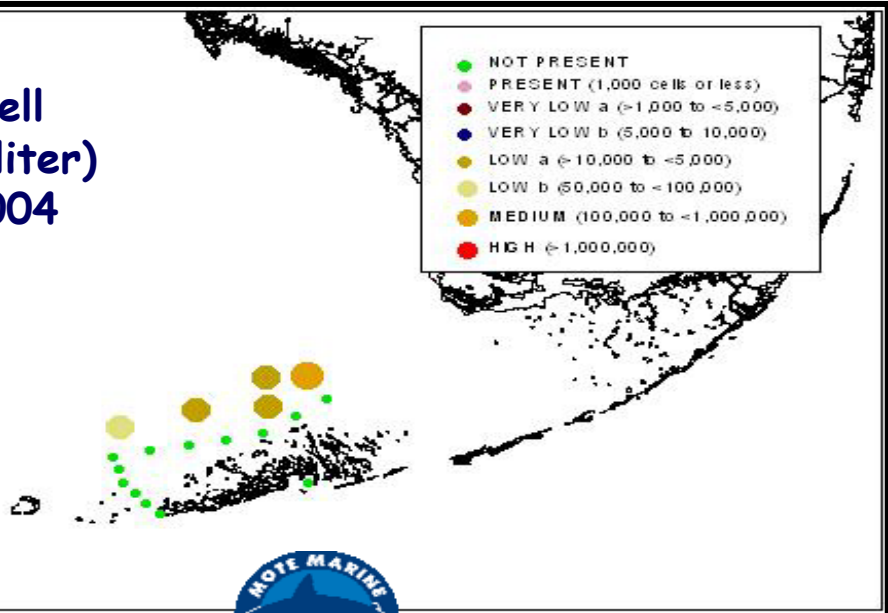
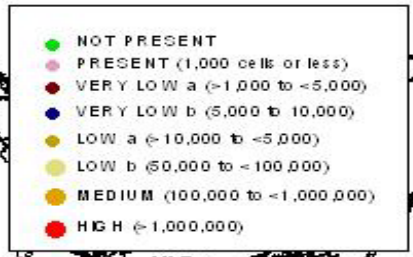
LAT: 17.00N - 31.00N

LON: 79.00W - 99.00W

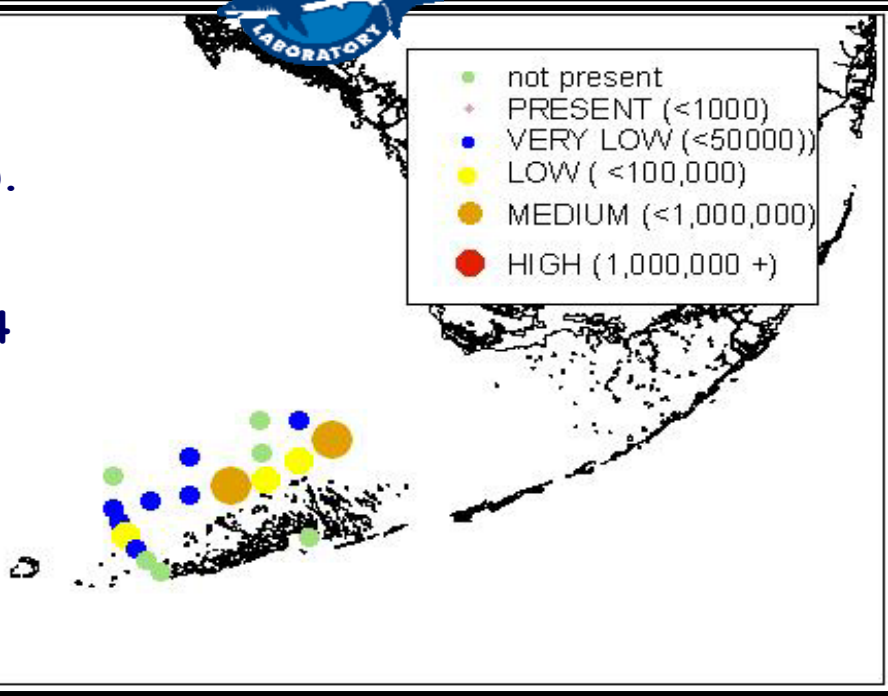
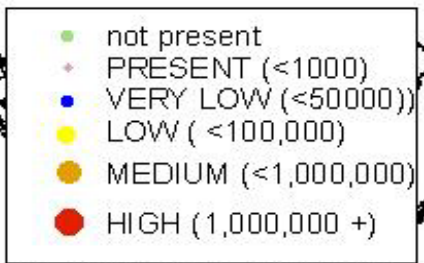




***K. brevis* Cell
Counts (cells/liter)
Dec. 22, 2004**

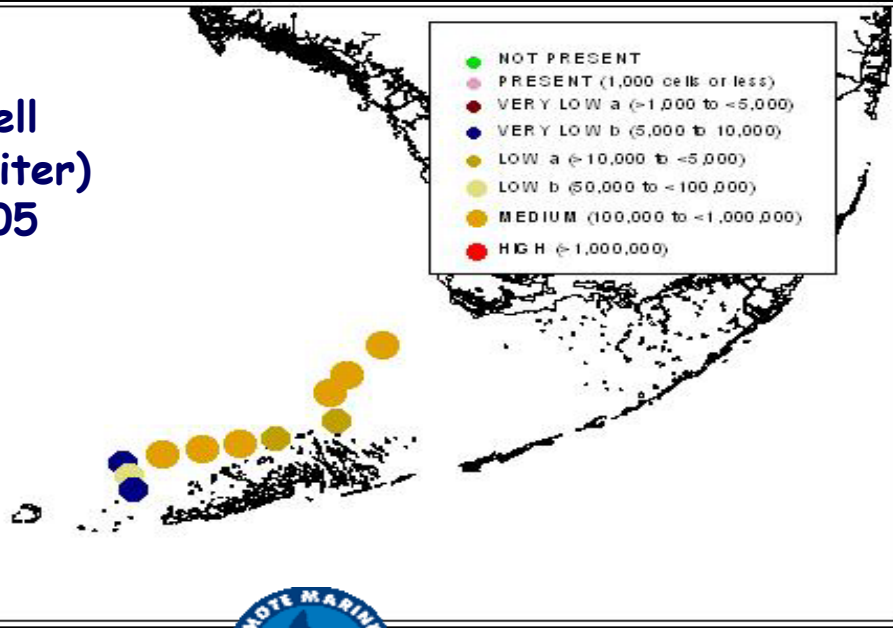


***Rhizosolenia* sp.
Cell Counts
(cells/liter)
Dec. 22, 2004**



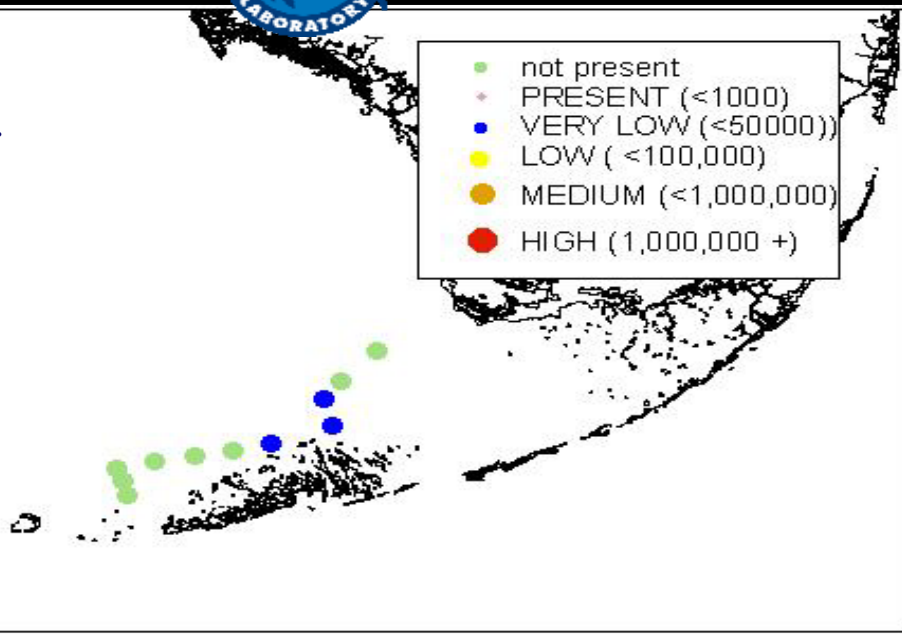
***K. brevis* Cell
Counts (cells/liter)
Jan. 6, 2005**

- NOT PRESENT
- PRESENT (1,000 cells or less)
- VERY LOW a (<1,000 to <5,000)
- VERY LOW b (5,000 to 10,000)
- LOW a (<10,000 to <50,000)
- LOW b (50,000 to <100,000)
- MEDIUM (100,000 to <1,000,000)
- HIGH (>1,000,000)



***Rhizosolenia* sp.
Cell Counts
(cells/liter)
Jan. 6, 2005**

- not present
- PRESENT (<1000)
- VERY LOW (<50,000)
- LOW (<100,000)
- MEDIUM (<1,000,000)
- HIGH (1,000,000 +)



Long-term Monitoring Program: South Florida and the FKNMS (1)

- South Florida Coastal Ocean Observations

- SEAKEYS C-MAN (Coastal-Marine Automated Network) Stations (FIO)

- Fixed instruments, near-real-time

- Cruises - instruments and samples

- Remote sensing

[rine.org/](http://marine.org/)

- Fixed instruments, periodic data collection

- Coastal Ocean Monitoring & Prediction System (USF COMPS): <http://comps.marine.usf.edu>

- Institute for Marine Remote Sensing (USF IMaRS): <http://imars.marine.usf.edu/>

- Coral Reef Watch (NOAA): <http://coralreefwatch.noaa.gov/satellite/ge/>

- Florida Keys BleachWatch Program, Current Conditions Reports (Mote): <http://isurus.mote.org/Keys/bleaching.phtml>

- FKNMS Thermographs (FKNMS)



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Long-term Monitoring Program: South Florida and the FKNMS (2)

- Sanctuary-Wide Status and Trends: Water Quality Protection Program
 - Water Quality (FIU SERC)

Spatial patterns

Temporal trends

Effects of no-take zones

Socioeconomic changes

Human knowledge and perceptions

- Spiny Lobster (FWC FWRI)

- Queen Conch (FWC FWRI) [protected state-wide since mid-80s]

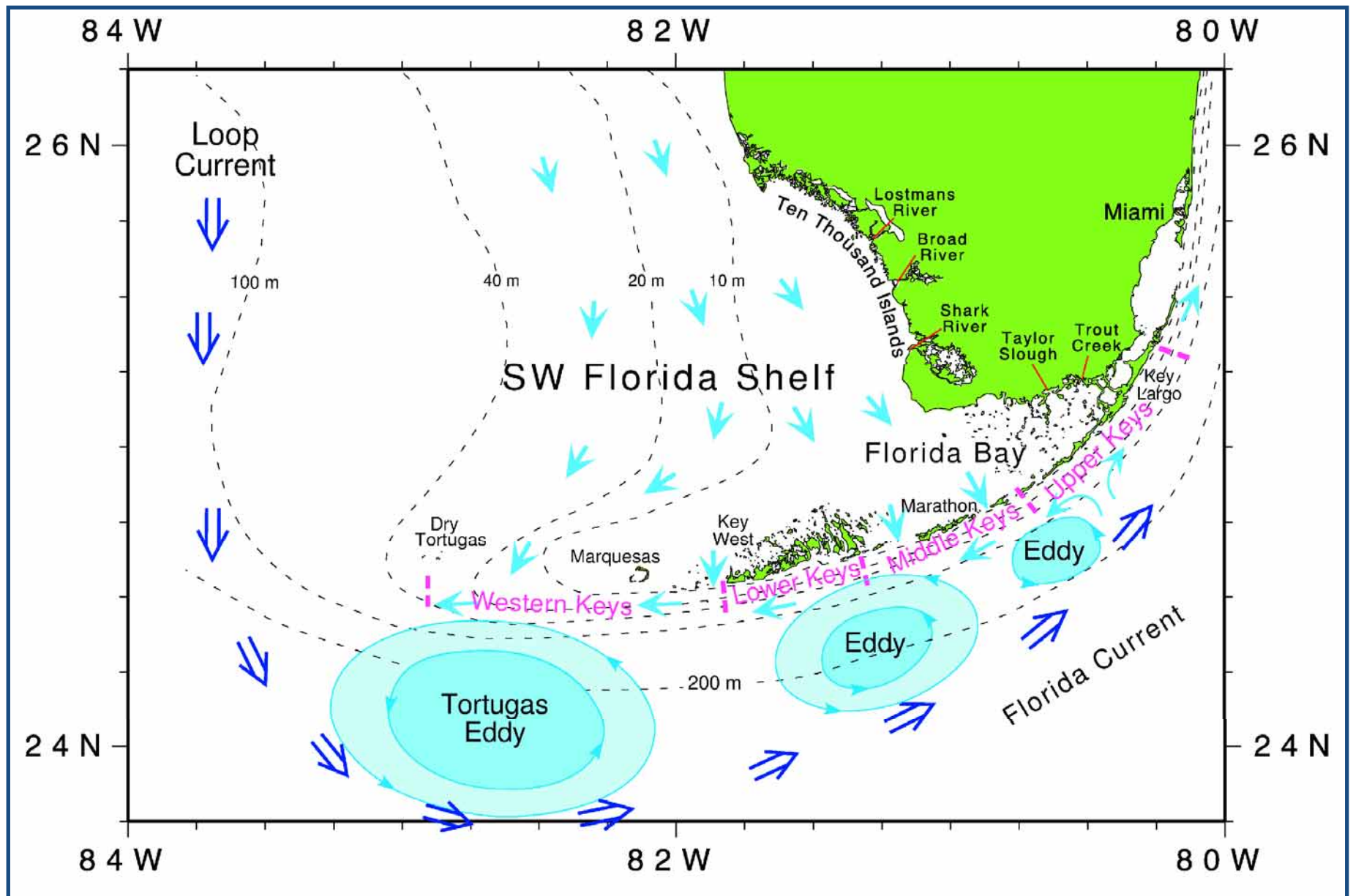
- Human Dimensions Research (NOAA/RSMAS/UMASS)

http://floridakeys.noaa.gov/research_monitoring/



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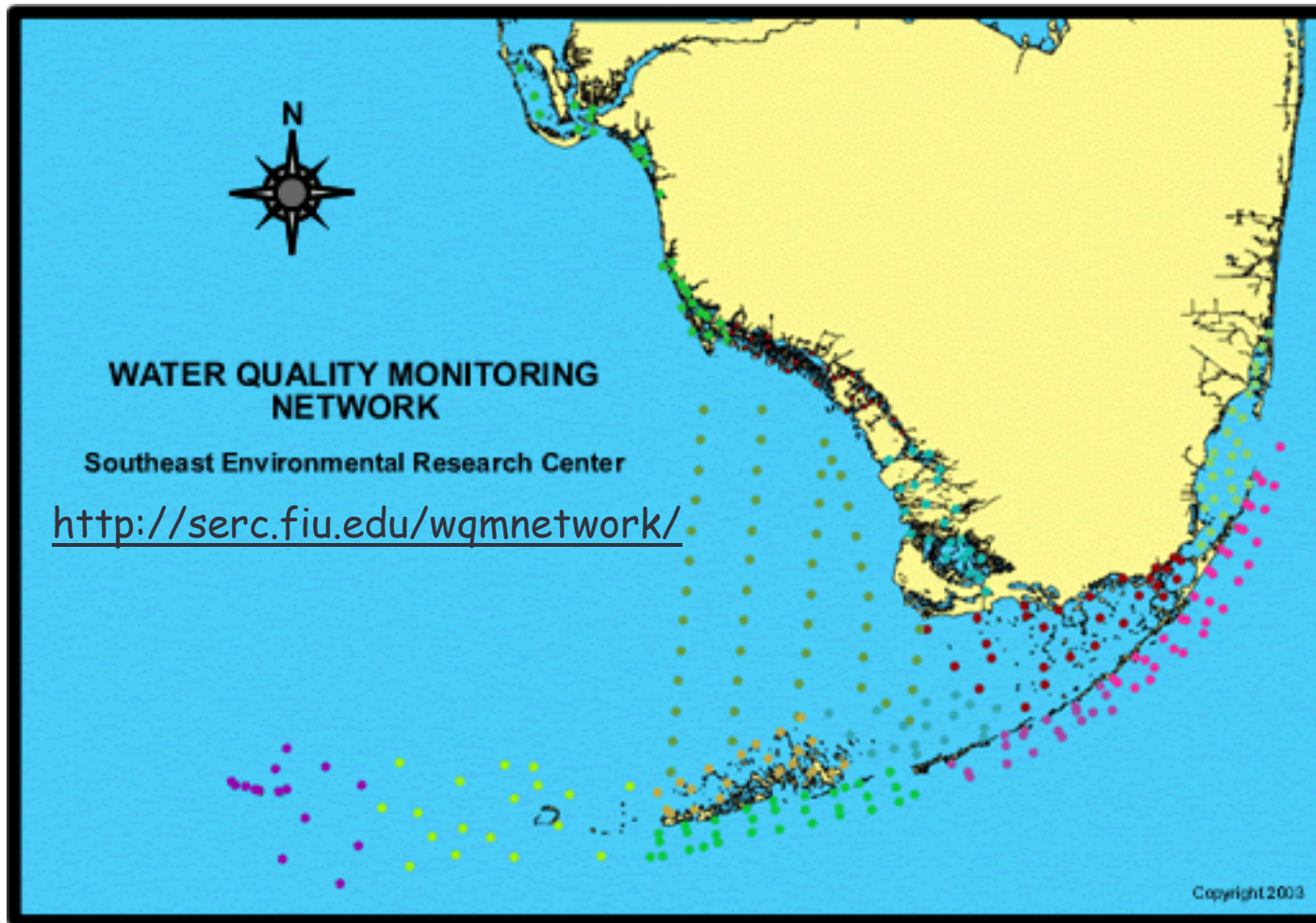
Lee et al. 2002

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Water Quality Monitoring Project

- Florida International University
- Water Quality Monitoring Network started in 1989
- FKNMS and Southwest Florida Shelf added in 1995

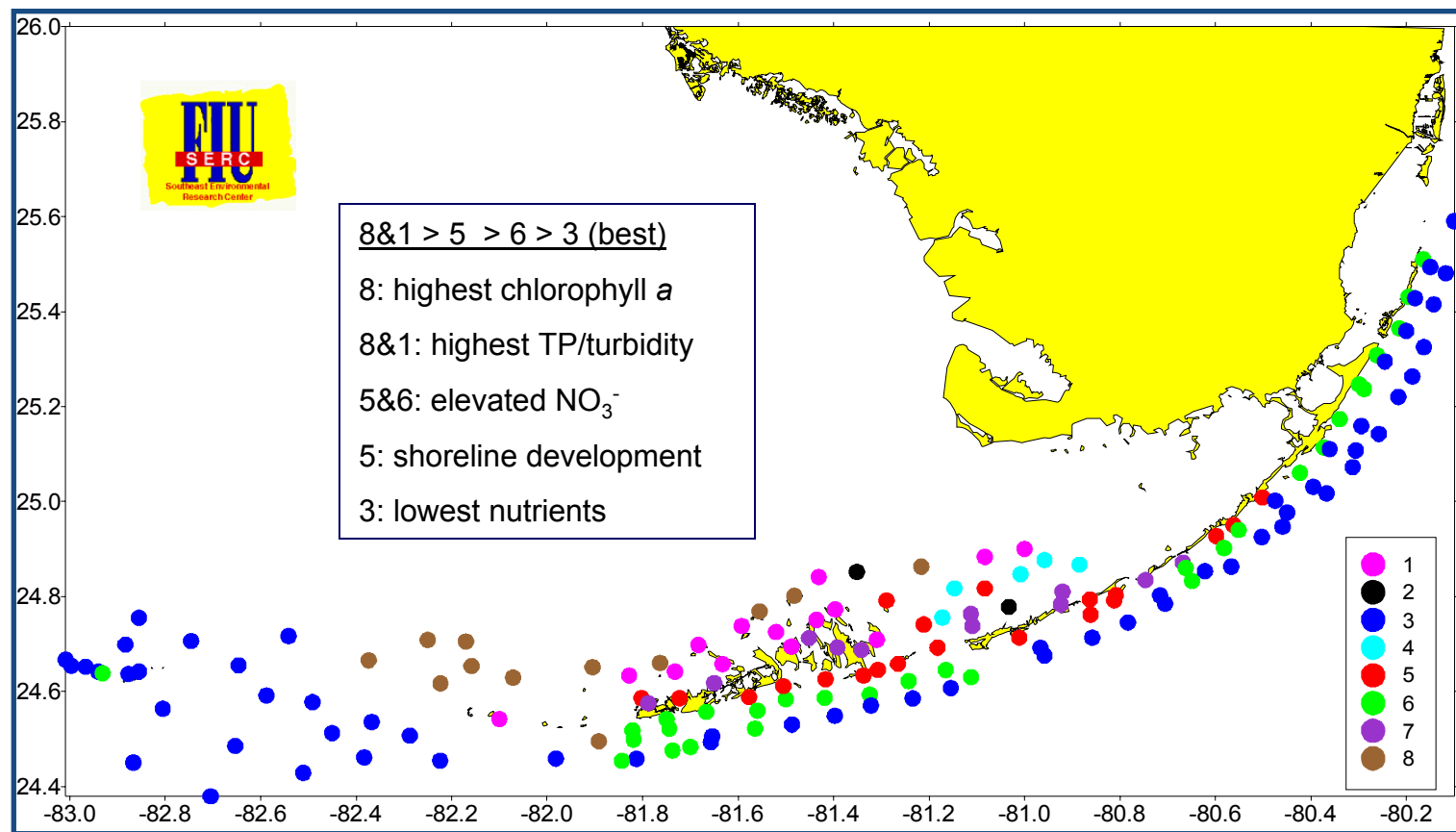


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Spatial Pattern, Temporal Trends

- Oligotrophic offshore water
- Onshore-offshore gradient along the Keys
- Significant multiyear trends in certain parameters have come and gone
- Large-scale oceanographic drivers of trends?



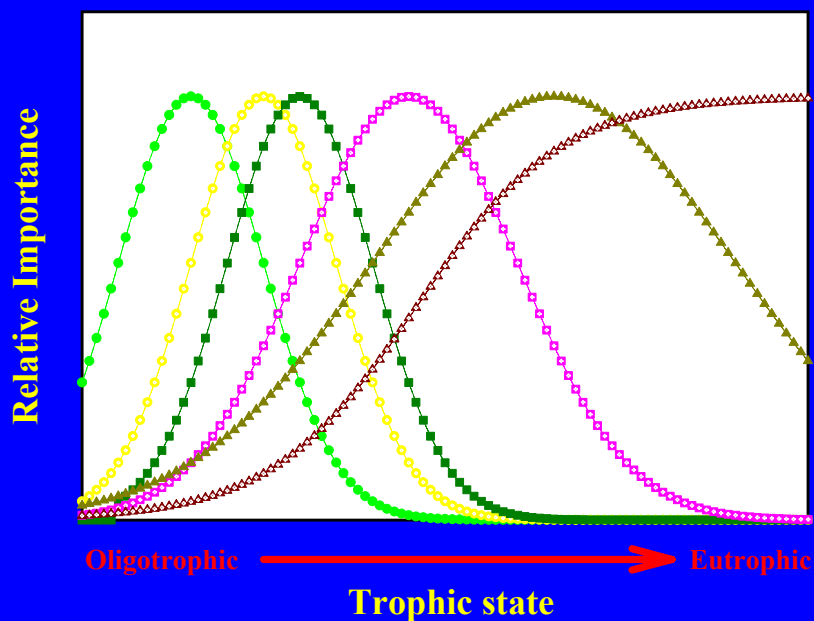
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Seagrass Monitoring Project

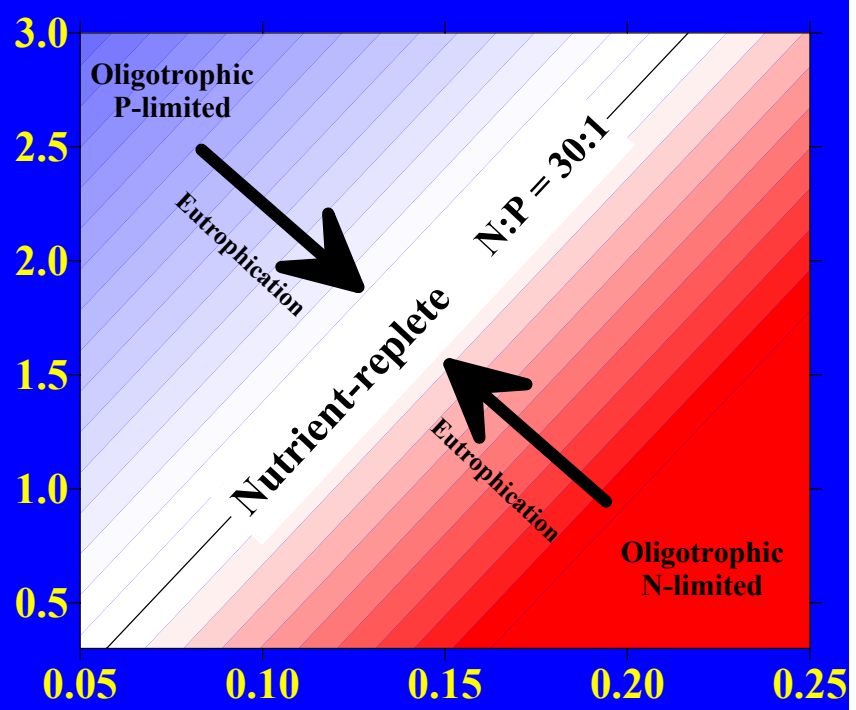
James W. Fourqurean, FIU
<http://www.fiu.edu/~seagrass/>

Eutrophication model



- *Thalassia testudinum*
- *Syringodium filiforme*
- *Halodule wrightii*
- *Ruppia maritima*
- ▲— Macroalgae
- △— Microalgae

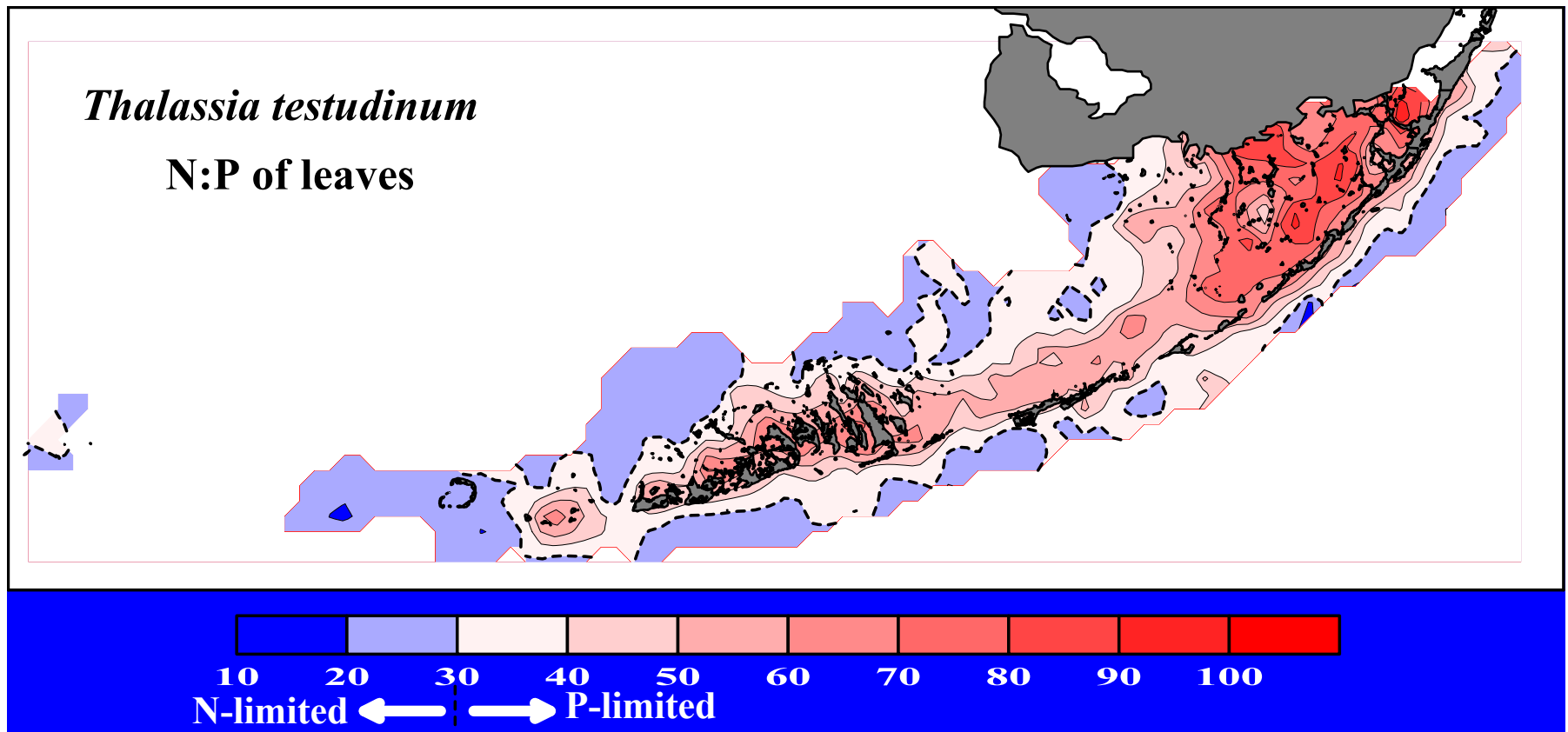
Leaf tissue N content (% of dry weight)



Leaf tissue P content (% of dry weight)
 May allow for detection of eutrophication
 before a change in species composition occurs



Spatial Pattern of Nutrient Limitation in South Florida



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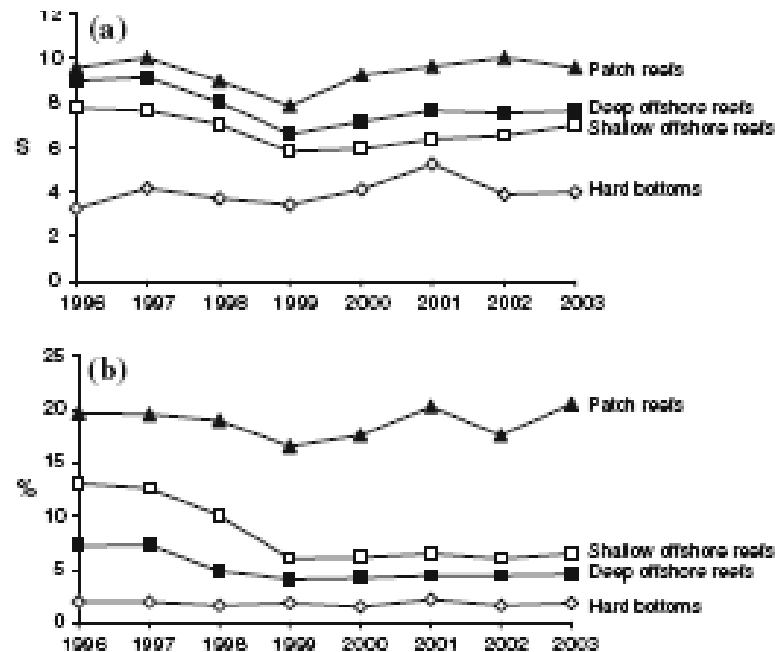
Coral Reef Evaluation and Monitoring Project

Coral Reefs
DOI 10.1007/s00338-008-0390-7

REPORT

Changes in coral reef communities among the Florida Keys, 1996–2003

P. J. Somerfield · W. C. Jaap · K. R. Clarke ·
M. Callahan · K. Hackett · J. Porter · M. Lybolt ·
C. Tsokos · G. Yanev



$N = 10$

$N = 12$

$N = 11$

$N = 4$

Fig. 2 (a) Mean number of species, and (b) mean total percent cover on hard bottoms (white diamonds), patch reefs (black triangles), shallow offshore reefs (white squares) and deep offshore reefs (black squares) 1996–2003

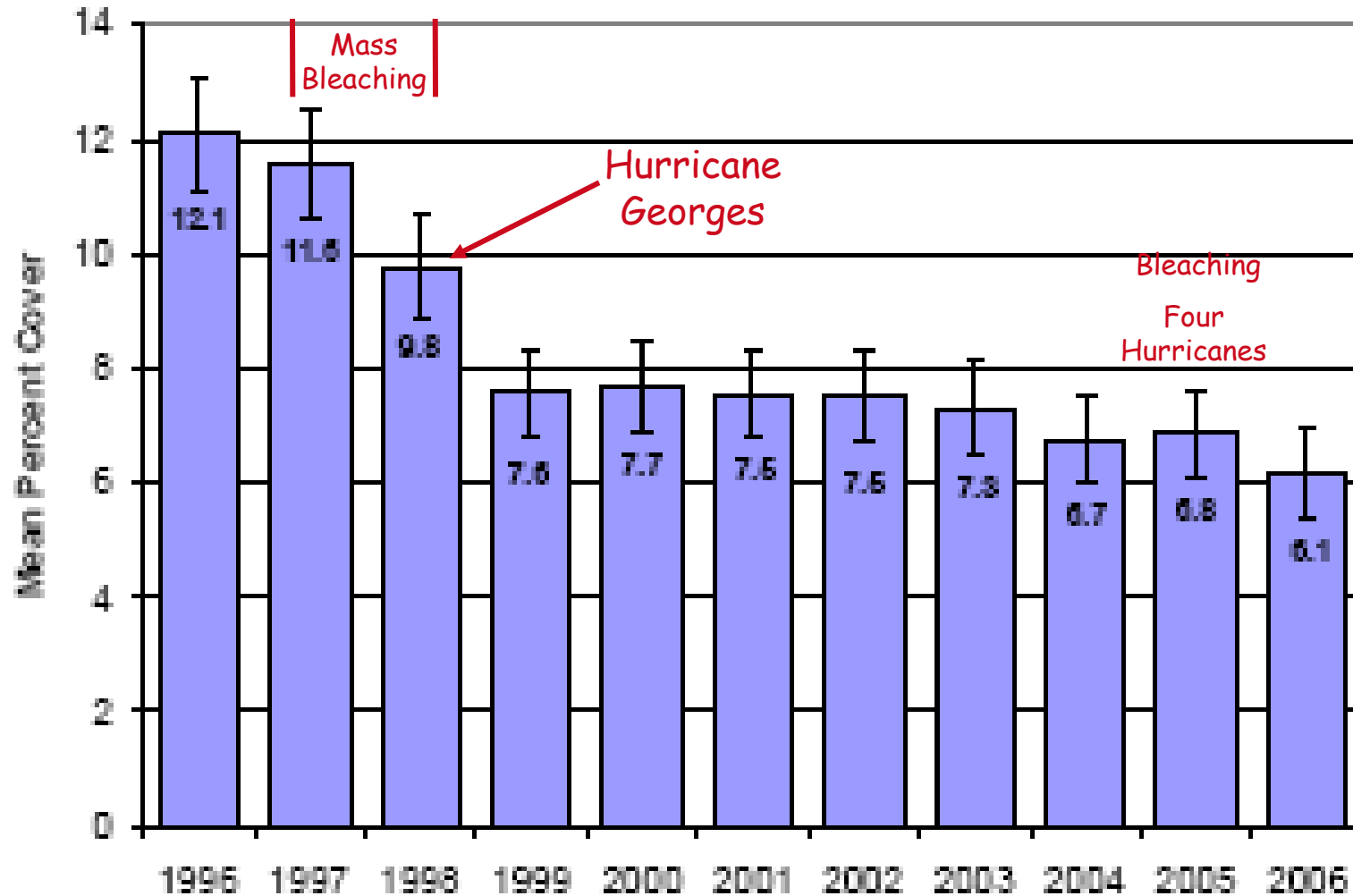


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CREMP: Overall Coral Cover Over Time

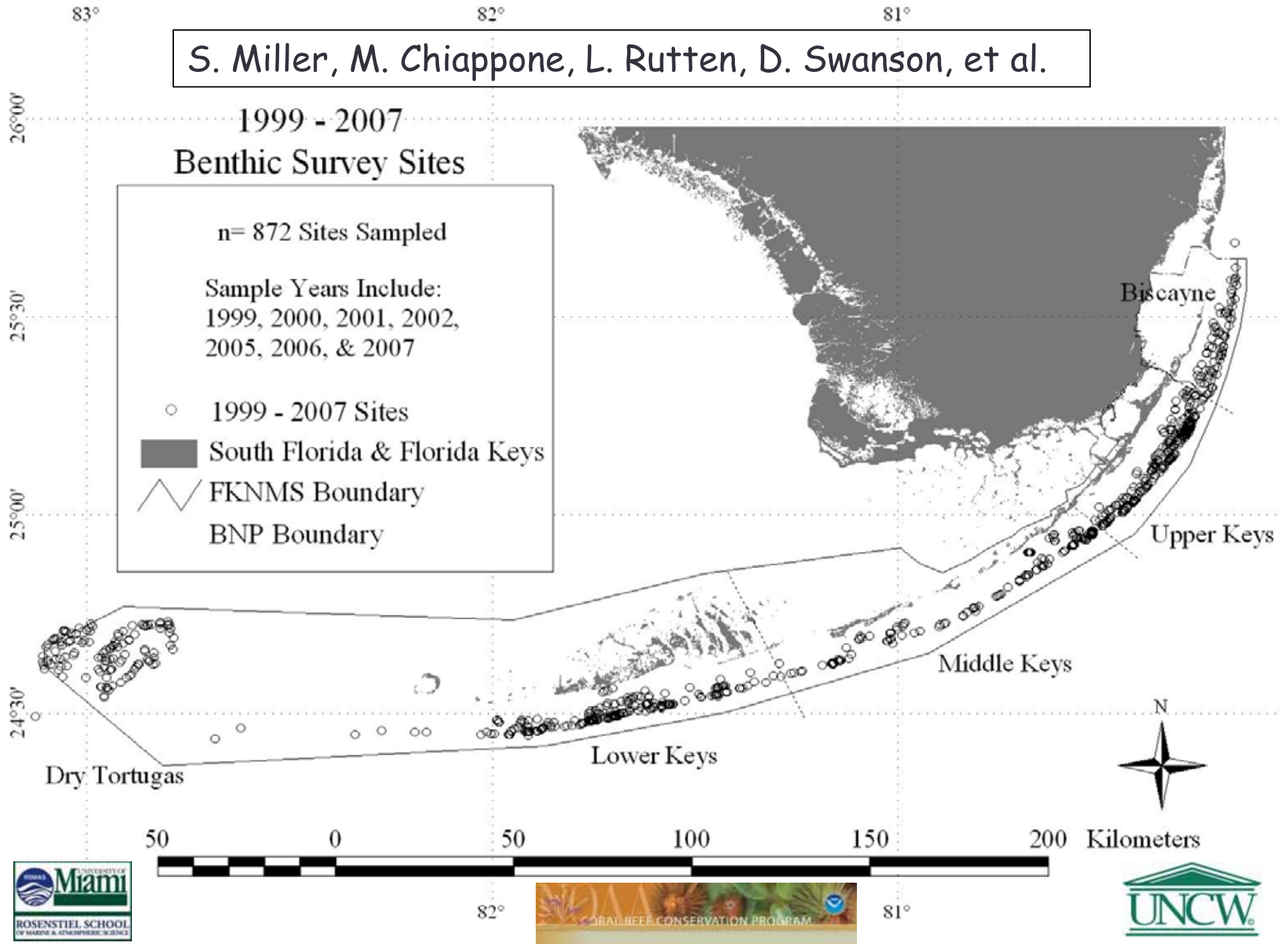
<http://www.floridamarine.org>



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S. Miller, M. Chiappone, L. Rutten, D. Swanson, et al.



Mid-channel Patch Reefs



South of Marathon



Marker 49



Cheeca Rocks SPA



Sunshine Key



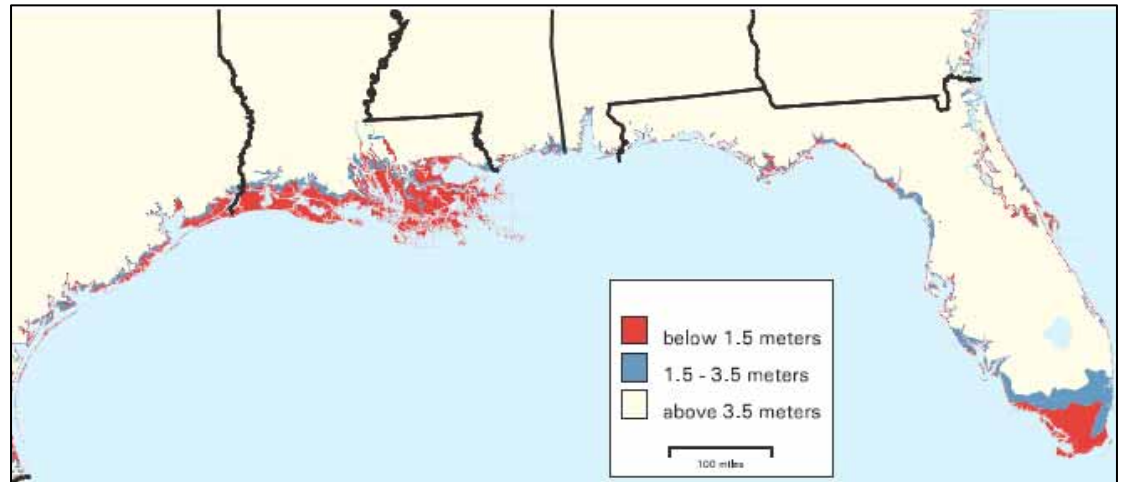
Conclusions

- Well-monitored marine ecosystem
- Potential for analyses of changes related to Everglades restoration
- Large-scale drivers appear to be important: oceanographic (multi-year water quality trends), warming (coral bleaching)
- Need for further cause/effect research
- Seagrass tissue N/P "early warning" for potential changes in species distribution and abundance
- Recent significant coral losses associated with major bleaching events and storms
- Climate change . . .



Climate Change Impacts

- Ocean Warming
- Ocean Acidification - reductions in calcification rates, e.g., corals, coralline algae → reef growth
- Rising Sea Level - part of Everglades = future extension of Florida Bay
- Storm Intensity - possible increased pulses of fresh water and increased physical damage
- Freshwater Influx



Source:

www.epa.gov/climatechange/effects/coastal/slrmaps



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Further Conclusions

- Climate change impacts likely will strengthen in their effects on South Florida marine ecosystem
- Adjusting management (“adaptation”) to climate change “buys some time”
- Need to greatly reduce greenhouse gas emissions



Acknowledgments

- Dauphin Island Sea Lab: R. Aronson, T. Murdoch
- Florida Institute of Oceanography: J. Fajans, J. Ogden
- Florida International Univ.: J. Boyer, J. Fourqurean, R. Jones
- Florida Fish & Wildlife Conservation Commission: C. Beaver, M. Callahan, W. Jaap, R. Ruzicka, J. Wheaton
- Georgia State Univ.: S.R. Smith
- Mote Marine Lab.: E. Bartels, C. Walter
- NOAA: J. Bohnsack, E. Johns, M. Miller, P. Ortner, R. Stumpf
- Univ. of Georgia: J. Porter
- Univ. of Miami/RSMAS: J. Ault, V. Kourafalou, T. Lee, J. Luo, G. Meester, S. Smith, D. Swanson
- Univ. of N. Carolina Wilmington/NURC: M. Chiappone, S. Miller, L. Rutten
- Univ. of S. Florida: C. Hu, M. Luther, F. Muller-Karger, R. Weisberg





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